(tome vii. of the Recueil) in 1827, the year of his death, and this is the paper which contains Fresnel's latest developments of his theory. In it he suppresses entirely his method of generalization and develops that mechanical theory by which, to quote his biographer Verdet, "he endeavoured to rediscover truths which a profound intuition had first revealed to him." The truths remain, and though Fresnel's methods and their historical development are clearly given in his collected works and in M. Verdet's most admirable introduction to them, Mr. Fletcher has done good service to science in calling fresh attention to these earlier papers and in making a modification of this method of Fresnel's the foundation of his work.

In his note to the first memoir, when discussing the inexact reasoning by which Fresnel afterwards supported his mechanical theory, Verdet writes ("Œuvres de Fresnel," ii., p. 327):—

> "Il pouvait sembler singulier que le résultat définitif d'un raisonnement incomplet et inexact en deux points fût une des lois de la nature dont l'expérience a le mieux confirmé la vérité. On a vu au contraire que cette loi s'était manifestée à Fresnel comme le résultat d'une généralisation toute semblable aux généralisations qui ont amené la plupart des grandes découvertes. Lors qu'il a voulu ensuite se rendre compte de la loi par une théorie mécanique il n'est pas étonnant qu'il ait, peutêtre à son insu, conduit cette théorie vers le but qu'il connaissait d'avance et qu'il ait été déterminé dans le choix des hypothèses auxiliaires moins par leur vraisemblance intrinsèque que par leur accord avec ce qu'il était en droit de considérer comme la vérité."

True though this may be, the fact remains that until Lord Kelvin developed his theory of a contractile ether a few years ago, no one of the distinguished men who have followed in Fresnel's steps had discovered a satisfactory mechanical basis for Fresnel's great generalization. But to return to the book before us. As has been mentioned, Mr. Fletcher's method of development differs somewhat from that indicated by Fresnel. He finds it more convenient to work with rays than with wave-normals or wave-fronts, and the construction he adopts is the following:—Draw a normal at any point of the ellipsoid of elasticity—the indicatrix in Mr. Fletcher's language. From the centre of the ellipsoid draw a line perpendicular to this normal, and consider a ray travelling in the direction of this perpendicular. Then the reciprocal of the intercept on the normal between the surface and the ray measures the velocity of propagation along the ray, and the plane of polarization of the ray touches the indicatrix at the point at which the normal is drawn. According to Fresnel's theory the radius vector drawn from the centre to this point is the direction of vibration in the ray, while according to the most recent modification of the theory, the motion takes place along the normal itself. From this simple construction the form of the wave-surface and all the known laws of the propagation of light in crystals are deduced in a strict and skilful manner. At the same time, while giving Mr. Fletcher the fullest credit for his originality, we are at times inclined to wish he had adhered more closely to Fresnel's method. He admits of course himself that a single ray cannot be propagated through the ether. We may hope that some of those who read his book will go on to study the mechanical theory of double refraction. Then they must deal with waves and not with rays, and they would find it an advantage to have had the one idea to guide them throughout. Again, the new method leads to a multiplicity of names for one and the same thing, and this is a disadvantage. We have ray-surface used for wave-surface, although the two are identical, nor is it easy at first to recognize the optic bi-normals and the optic bi-radials as the optic axes and the lines of single ray velocity respectively; but these are small points when compared with the main object of the book, which well deserves attention and careful study. The last chapter deals with the problem in a more general way, but space forbids us to follow Mr. Fletcher into the questions he there raises; it must suffice to call the reader's attention to it, and especially to the fallacy discussed in Section 17.

R. T. G.

THE PROGRESS OF HORTICULTURE.

Contributions to Horticultural Literature. By William Paul, F.L.S. (Waltham Cross, Herts: W. Paul and Son, 1892.)

FOR about half a century Mr. Paul has been labouring at the work of horticulture alike in the garden and at the desk. As a business man he has not confined himself simply to commercial routine. As an observer and an experimenter he has not been hedged in by the dogmas and prejudices of any particular school of science, and as a writer his aim has always been to record truthfully and instruct faithfully. It is a matter of congratulation, therefore, that the author should have gathered together in a convenient form some records of a lifetime's work.

Certain portions we should have eliminated as of past or of personal interest only; certain others as of relatively minor importance; but Mr. Paul is addressing a mixed audience with varied sympathies and interests, and it may be that the paragraphs we should mark for deletion would be those which others would best care to preserve.

Mr. Paul groups his writings, as here collected, under the three heads of (1) roses, (2) trees and plants, and (3) fruit culture and miscellanea. They would fall equally well under other categories, such as the commercial and practical, the æsthetic and the biological. In this notice we must confine ourselves to Mr. Paul's writings as a naturalist. Such, however, is the interdependence among various branches of inquiry, that it is almost impossible, in this connection to isolate any special subject, even if it were desirable to do so. From this point of view Mr. Paul's book is, though undesignedly, an apt representation of the present condition of horticulture. On the one hand, the relations of that art to the perception of and to the canons of beauty are obvious. Equally clear are its bearings on routine practice. On the other hand, its connection with biological science, in spite of the teaching and example of Darwin, is not yet adequately recognized; nor has the statesman as yet grasped the truth that progress in agriculture must follow to a large extent on the lines familiar to horticulturists. Of the many remedies proposed to mitigate and clear away the depression under which agriculture is suffering, none is more likely to be serviceable than the adoption, so far as

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circumstances permit, of the principles and practice of the progressive gardener. This is very obvious to those conversant with the state of commercial horticulture, as contrasted with the condition of the corresponding department of agriculture, and it will be brought home to the thoughtful reader by the perusal of some of Mr. Paul's pages. It is interesting, too, to see that matters at which some minds would still be inclined to scoff as unpractical, or which they would regard as mere means of affording agreeable recreation, are the very departments in which the greatest practical successes have been achieved in the past, and which are of the best augury for progress in the future.

Biologically speaking, Mr. Paul has been not only a keen observer but a careful experimenter on a very large scale, and over a very long period. It is true his experiments have not been and could not have been made with the exact accuracy which we expect in the laboratory, but they have been made under conditions far more akin to those which occur in nature. Moreover, they have been made, although with a definite aim, yet without reference to any particular theory. The reader will accordingly find in these pages records of work and inferences from carefully planned experiments directly bearing on many subjects now attracting the attention of naturalists, such as hereditary transmission, variation from seed or from bud, selection, fixation, close fertilization, and the various degrees of cross-impregnation. Incidentally these subjects receive illustration in many chapters of Mr. Paul's book ; but the address on "The Improvement of Plants," which was read in 1869 before the provincial meeting of the Royal Horticultural Society at Manchester, contains a summary of Mr. Paul's views on these subjects, which we strongly commend alike to the notice of naturalists and of agriculturists.

It is very interesting to compare what he says about selection and variation in plants, such as the Camellia, the Chinese Primrose, or the Hollyhock, which are the offspring of what we regard as pure species, with the corresponding processes in the Rose, the Pelargonium, or the Chrysanthemum, which are veritable mongrels. In this connection we may in passing allude to the power which the gardener has, of course within limitations, of creating new forms. The orchid cultivator, for example, inferred parentage of certain hybrids met with in a wild state, but he has since proved the correctness of his inference by actually producing in his orchid-house many of the same forms that occur in the forests of the tropics. Another very striking case (not specially alluded to by Mr. Paul) is the production and development of what are known as tuberous Begonias. These have been evolved by the art and patience of the gardener within the last quarter of a century from repeated crossing between certain Andean species of Begonia and their descendants. The result is the establishment of a race so totally distinct from anything yet known in nature as would justify a systematic botanist in forming a separate genus for their reception. Many an accepted genus is based upon less important points of distinction than those which characterize the tuberous Begonias, and which, indeed, have been gathered together by Fournier under the genus Lemoinea. The degree of permanence of this artificially formed genus is, of course, unknown ; but we do know already that the peculiarities are reproduced from seed, and that each year the plants are, as the gardeners say, becoming more "fixed." We have alluded to these as illustrations of the kind of work upon which Mr. Paul has been engaged for half a century. They may be taken as examples of the material he has gathered together in this book, which is not merely presented for the delectation of the ordinary lover of flowers or the profit of trading horticulturists, but is also calculated to increase the productive resources of the country, as well as to forward the progressive development of our knowledge of the natural history of plants.

As a further illustration of Mr. Paul's method we cite in conclusion a passage which will, we think, justify us for recommending to scientific readers the perusal of a book which they might be disposed, from its title, to think had little in it to interest them. "My experience in selecting, hybridizing, and cross-breeding tells me that he who is seeking to improve any class of plants should watch narrowly and seize with alacrity any deviation from the fixed character, and the wider the deviation the greater are the chances of an important issue. However unpromising in appearance at the outset, he knows not what issues may lie concealed in a variation, sport, hybrid, or cross-bred, or what the ground newly broken is capable of yielding under careful and assiduous cultivation. If we would succeed in this field we must observe, and think, and work. Observation and experiment are the only true sources of knowledge in nature, and while observing and experimenting we should above all things guard against prejudices."

MAXWELL T. MASTERS.

LIFE IN MOTION.

Life in Motion; or, Muscle and Nerve. By John Gray McKendrick, M.D., F.R.S. (Adam and Charles Black, 1892.)

UNDER this title Prof. McKendrick gives us the gist of six lectures delivered by him during last Christmas holidays to a juvenile audience at the Royal Institution of Great Britain ; and, judging from this little work, it is evident that no pains was spared by him to render these lectures as instructive and interesting as abundant illustrations and experiments could make them. In presenting these lectures to the public in book form he places us under an obligation gratefully to be acknowledged, for professional physiologists stand alone amongst their colleagues in other departments of science in their disdain of any attempt at the production of attractive and simple scientific literature. In very pleasing sympathetic style the reader is introduced to the world of motion and to the special motions of the living muscle. He is shown how the movements of a muscle are recorded by the physiologist, and the apparatus used for its stimulation. Artificial tetanus is described, the muscle sound and its elasticity referred to, and a perhaps too short description given of amœboid and ciliary motion. The physiology of the nerve is then discussed, and the production of heat in muscle. In the fifth lecture is a short account of the sources of muscular energy, a comparison is drawn between a muscle and the steam-engine, and a comparatively detailed account of muscle fatigue is given.

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